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PATENT

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SIGNAL-TO-NOISE OPTIMIZED FULLY MONOLITHIC

VIDEO RECEIVER IF CHANNEL

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SIGNAL-TO-NOISE OPTIMIZED FULLY MONOLITHIC VIDEO RECEIVER IF CHANNEL

TECHNICAL FIELD OF THE INVENTION

This invention relates to a video-receiver IF channel, and more particularly, to partitioning the gains in the IF channel so that the signal-to-noise ratio is optimized in a fully monolithic video receiver.



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BACKGROUND OF THE INVENTION

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If a video-receiver is to be fully integrated, then a monolithic filter must be used, as opposed to a partially integrated or a discrete receiver using a discrete filter. In the case of a partially integrated receiver using a discrete filter, a problem is created in that the system would have to be provided with a board, and more than likely, a metal case around it, which is relatively costly.

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Fully-monolithic receivers differ from their discrete counterparts primarily due to a lack of low-loss monolithic inductors. For this reason, most of the filtering function on such receivers must be realized with active simulations of inductors. However, active fully-monolithic intermediate frequency (IF) filter-amplifiers suffer from detrimental noise characteristics of the active devices required to simulate inductors. This performance is further aggravated in the case of an IF filter-amplifier providing additional high-gain to the channel.

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In a discrete realization, placing a variable gain amplifier (VGA) after an IF filter, helps its noise performance by band limiting, since a discrete inductance/capacitance (LC) IF filter is practically noiseless. However, in a fully-monolithic circuit, placing a high-gain VGA after the IF filter, which is the major source of noise, results in a substantially increased noise level leading to a reduced signal-to-noise (S/N) ratio. Moreover, in such a structure, the distortion of the filter changes with a widely varying signal, such that if the linearity is made sufficient for the highest signal levels, it becomes suboptimal for the low signal levels.

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In the case of low-VGA gain, the IF channel noise performance is acceptable. However, in the high-gain case, the amplitude of the input signal to the filter is the amplitude of the output signal divided by the gain of the VGA, and such a reduced input signal to the filter results in a substantial deterioration of the system S/N ratio. The S/N ratio is

defined as the ratio of the maximum undistorted rms input signal of the filter to the input referred noise of the filter.

Accordingly, there is needed a fully monolithic IF channel which allows a wide gain range while still maintaining an acceptable S/N ratio, all without using off-circuit LC devices.

It is, therefore, an object of the present invention to provide a fully-monolithic IF channel receiver system that has the improved signal processing noise capabilities.

Another object of the invention is to provide a fully-monolithic receiver, therefore reducing its manufacturing cost.

Yet another object of the present invention is to provide the IF band-pass filter with the maximum possible input signal in order to maintain the signal/noise ratio.

A further object of the present invention is to provide a constant signal level input to the IF band-pass filter, and therefore, optimize its linear range and distortion, and save dissipated power.

SUMMARY OF THE INVENTION

In accordance with the present invention, a modified configuration of a fully-monolithic active IF channel is provided. The system consists of two amplifiers, a VGA (a variable gain amplifier), and an FGA (a fixed gain amplifier), as well as two filters. A low-pass filter precedes the VGA, and an intermediate frequency band-pass filter follows the VGA and precedes the FGA.

In order to achieve an optimum S/N ratio condition, a filter should always operate with the maximum possible input signal. Therefore, a VGA precedes the IF band-pass filter, which is then followed by an FGA. In such a configuration, the maximum possible gain is applied by the VGA in front of the filter, so that only a portion of the gain, that of the FGA after the filter, amplifies its noise. Additionally, the input referred noise of the present system becomes the input referred noise of a VGA which can be made lower than that of an IF filter.

One technical advantage to the present configuration, is that since the signal input level to the filter is kept constant, its linear range can be optimized so that the distortion is always maintained within the specification. Moreover, no matter what the input signal to the channel is, the filter always utilizes the entire amount of the available linear range, which directly translates into a saving of dissipated power.

The present invention has only small changes in its S/N ratio, and in the worst case it has a S/N ratio that is several tens of dBs better when compared to the classical solution. Moreover, the net improvement in the S/N ratio between the worst case for the classical solution and the worst case for the present invention, is equal to the ratio of the maximum VGA gain in the classical case over the FGA gain in the present invention, multiplied by the input referred noise of the

VGA in the present invention over the input referred noise of the IF filter, which for both cases is assumed to be the same.

Thus, in accordance with one aspect of the present invention, there is provided a monolithic system for processing ^{radio frequency (RF)} RF signals, which includes an amplifier for bringing the input signal up to a level for processing by an IF monolithic filter whereby the output of the filter is sent to an FGA. Preferably, a first filter is used ahead of the first amplifier to reduce noise and distortion falling in the higher bands, and this filter is a low-pass filter. The second filter is an intermediate frequency, band-pass filter. Also, preferably, the first amplifier would be a VGA and the second amplifier would be an FGA.

In accordance with another aspect of the present invention, there is provided a method for processing RF signals, comprising the steps of receiving an input RF signal; mixing the input RF signal with an operating frequency signal to generate a first signal; filtering the first signal to generate a second signal; amplifying the second signal to generate a third signal; filtering the third signal to generate a fourth signal; and amplifying the fourth signal to generate a fifth signal.

Preferably, the step of filtering the first signal to generate a second signal includes processing the first signal through a low-pass filter. Also, preferably, the step of amplifying the second signal to generate a third signal includes amplifying the second signal by a VGA.

With respect to additional preferred embodiments, the step of filtering the third signal to generate a fourth signal includes processing the third signal through an intermediate-frequency band-pass filter. Also, the step of amplifying the fourth signal to generate a fifth signal includes amplifying the fourth signal by an FGA.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood.

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Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic representation of the fully-monolithic IF channel video-receiver according to the present invention.

FIGURE 2 is a schematic representation of a prior art discrete video-receiver.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Before beginning a discussion of the operation of the invention, it might be well to review the prior art discrete circuits in relation to FIGURE 2.

FIGURE 2 describes the classical arrangement for an IF channel. It consists of mixer 21, which is then connected to low-pass filter 22. The output signal from LPF 22 is then passed through an IF band-pass filter 23. Because the channel is discrete, and the IF filter is either an LC Network with some discrete amplifiers or a SAW (surface acoustic wave) filter, the noise through this IF filter is minimal. After the IF filter, the signal enters variable gain amplifier (VGA) 24, which can have a maximum gain as high as 10,000.

FIGURE 1 shows the present invention, which changes the gain partitioning in the channel as compared to the prior art shown in FIGURE 2. As in the discrete receiver, the first block is mixer 11, followed by a low-pass filter 12. Next, comes VGA 13 in front of IF band-pass filter 14, which is then followed by fixed gain amplifier (FGA) 15. The advantage of this improvement is to partition gains so that the signal in front of IF filter 14 is maximized. The input signal to IF filter 14 advantageously should be the maximum possible signal that the filter can receive.

Therefore, in the preferred embodiment, VGA 13 has the characteristic that it can amplify the signal coming from the mixer to the maximum level that the IF filter can take. If additional gain is needed, this gain is provided by the FGA 15. Since the output level of IF band-pass filter 14 is a known level, a fixed gain amplifier can be used as the last stage. Any noise induced by IF band-pass filter 14 is only amplified by the FGA gain and not by say 10,000, as in the worst case of the prior art.

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One problem is that the input signal level to VGA 13 varies, in that it can be weak or strong in an unpredictable fashion. The present invention controls this situation by use of a variable gain, such as VGA 13, such that its output signal is constant. This constant value is the maximum that the IF filter can accept which depends on the definition of distortion in the system. Therefore, a level of distortion must be chosen, and then the remaining components can be decided upon. If the IF stage can take the full gain, the output amplifier would not be required.

10 In one preferred embodiment, if the distortion level is chosen at 1%, and this is achieved for 200 mV input signal to the ~~IF~~ filter, then 15 the output signal of VGA 13 should never exceed 200 mV. Otherwise, distortion greater than 1% would be introduced into the IF filter.

15 Note, that while a single substrate is contemplated, the 20 monolithic device can have more than one substrate. Also note that, while video is discussed, this concept could be used with any IF communication channel.

The present invention, therefore, is well adapted to carry out the objects and obtain the ends and advantages mentioned as well as others inherent therein. While presently preferred embodiments of the invention have been given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts will be readily apparent to those skilled in the art and which are encompassed within the spirit of the invention and the scope of the appended claims.